

ALICE measurements of heavy-flavour production in pp and p-Pb collisions at the LHC

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Abstract

The D meson yields as a function of charged-particle multiplicity in pp collisions at $\sqrt{s} = 7$ TeV and in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV are presented. The measurement of the yields of electrons from heavy-flavour hadron decays as a function of charged-particle multiplicity in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV are shown as well. The measurement of azimuthal correlations of prompt D mesons and charged hadrons in pp collisions at $\sqrt{s} = 7$ TeV and in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV are also presented. The results are compared with expectations from models.

Keywords: ALICE, heavy-flavour, correlations

1. Introduction

The study of the production of hadrons containing charm and beauty quarks in proton-proton (pp) collisions at the LHC provides a way to test calculations based on perturbative QCD at high collision energy. In p-Pb collisions, heavy-flavour hadron production is sensitive to Cold Nuclear Matter (CNM) effects such as the modification of the parton distributions functions in the nucleus at small Bjorken- x (see e.g. [1]), the parton energy loss in the initial stages of the collision via initial-state radiation [2] and the transverse momentum broadening due to soft scatterings of the partons in the incoming nucleus [3].

In addition to transverse momentum and rapidity differential distributions, measurements as a function of multiplicity and studies of angular correlations provide further constraints on the description of heavy-flavour production in pp and p-Pb collisions. The measurement of heavy-flavour production in pp collisions as a function of the charged-particle multiplicity could provide insights into the role of multi-parton interactions (MPI) and the interplay between hard and soft mechanisms in particle production. The multiplicity-differential measurements of heavy-flavour production in p-Pb collisions

are sensitive to the dependence of CNM effects on the collision geometry and on the density of final-state particles. The measurement of azimuthal correlations of D mesons and charged particles in pp collisions provides a way to characterize charm production and fragmentation processes, while in p-Pb collisions they could give insights into possible collective effects in small systems.

The excellent performance of the ALICE detector [4] allows for open heavy-flavour measurements in several decay channels and in a wide rapidity range. This contribution focuses on the measurements at mid-rapidity where open heavy-flavour production is studied by means of fully reconstructed D mesons (in the decay channels $D^0 \rightarrow K^-\pi^+$, $D^+ \rightarrow K^-\pi^+\pi^+$, $D^{*+} \rightarrow D^0\pi^+ \rightarrow K^-\pi^+\pi^-$, $D_s^+ \rightarrow \phi\pi^+ \rightarrow K^-K^+\pi^+$ and their charge conjugates) and in the semi-electronic decay channels.

2. Heavy-flavour production as a function of multiplicity

The study of heavy-flavour production as a function of the charged-particle multiplicity is presented via the self-normalised yields, i.e. the corrected per-event yield in a given multiplicity interval normalised to the

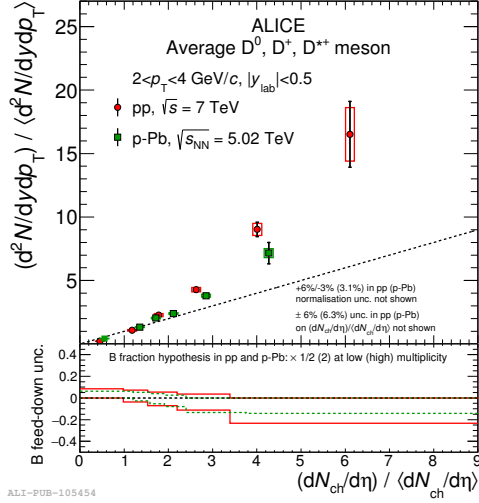


Figure 1: Self-normalised yields of D mesons as a function of the charged-particle multiplicity estimated at mid-rapidity in pp (red) and p-Pb (green) collisions.

multiplicity-integrated value. Multiplicity intervals at mid-rapidity are defined by measuring the number of tracklets (track segments joining a pair of particle hits in the two layers of the Silicon Pixel Detector and aligned with the reconstructed primary vertex) in the pseudo-rapidity interval $|\eta| < 1$. The number of tracklets is converted to the charged-particle multiplicity at mid-rapidity ($dN_{ch}/d\eta$) by means of a Monte Carlo simulation. D^0 , D^+ and D^{*+} self-normalised yields are compatible with each other within uncertainties in the analyzed multiplicity and p_T intervals. The average D^0 , D^+ and D^{*+} self-normalised yields as a function of the charged-particle multiplicity at mid-rapidity in pp collisions and in p-Pb collisions are shown in Fig. 1. A similar faster-than-linear increasing trend with charged-particle multiplicity is observed in the two colliding systems. In Ref. [5] it is reported that the measurement in pp collisions is qualitatively described by model calculations taking into account the influence of the interactions between colour sources in the percolation model [6], and the contribution of MPI, through the PYTHIA8 [10] as well as the EPOS3 event generators [7].

Figure 2 reports the self-normalised yields of electrons from semi-leptonic heavy-flavour hadron decays as a function of the charged-particle multiplicity estimated at mid-rapidity, compared with the D meson measurement. The different kinematic ranges for the two observables in each panel approximately account for the effect of the decay kinematics. In each panel ac-

count for the decay kinematics. The increasing trend of D mesons and electrons from decay of heavy flavour hadrons is compatible within uncertainties. No dependence on the electron transverse momentum is observed also for $p_T > \sim 4$ GeV/c where a strong contribution from beauty-hadron decays has to be considered. The measurement gives a hint that the production mechanisms of charm and beauty as a function of the multiplicity are similar in p-Pb collisions. The results from model calculations using EPOS3 event generator [7] for D mesons considering two approaches, i.e. with and without hydrodynamical evolution of the simulated initial conditions, are also shown. The calculations using a hydrodynamic evolution are in better agreement with the faster-than-linear increase of the D-meson measurement, suggesting that collective effects could play a role in particle production in high-multiplicity p-Pb collisions.

3. Azimuthal correlations

The azimuthal correlations are built by calculating the difference in $\Delta\eta$ and $\Delta\phi$ between a reconstructed D meson (trigger particle) and the primary charged particles (associated particles) [8]. Corrections for limited detector acceptance, spatial inhomogeneities, trigger and associated particle selection efficiency, as well as secondary track contamination are applied. The contribution due to the azimuthal correlations of D mesons from beauty-hadron decays and charged particles is obtained with PYTHIA simulations and subtracted. Different ranges of the D-meson ($3 < p_T^D < 16$ GeV/c in pp, $5 < p_T^D < 16$ GeV/c in p-Pb) and associated particle p_T (starting from $p_T^{assoc} > 0.3$ GeV/c) are studied. The azimuthal correlation distribution is fitted with two Gaussian functions (one for the near-side peak centred at $\Delta\phi = 0$ and one for the away-side peak centred at $\Delta\phi = \pi$) on top of the baseline. The baseline is calculated from the region $\pi/4 < |\Delta\phi| < \pi/2$, and its variation upon redefinition of this interval is treated as a systematic uncertainty. Figure 3 compares the baseline-subtracted D meson-charged particle azimuthal correlation distributions extracted in pp collisions with predictions by PYTHIA6 [9], PYTHIA8 [10] and POWHEG+PYTHIA6 [11, 12] simulations, as a function of the D-meson p_T , for different associated particle p_T ranges. The simulations reproduce the azimuthal correlation distributions within uncertainties, though a hint for a more pronounced near-side peak in data than in models is visible in the $8 < p_T^D < 16$ GeV/c range. The parameters extracted from the fit to

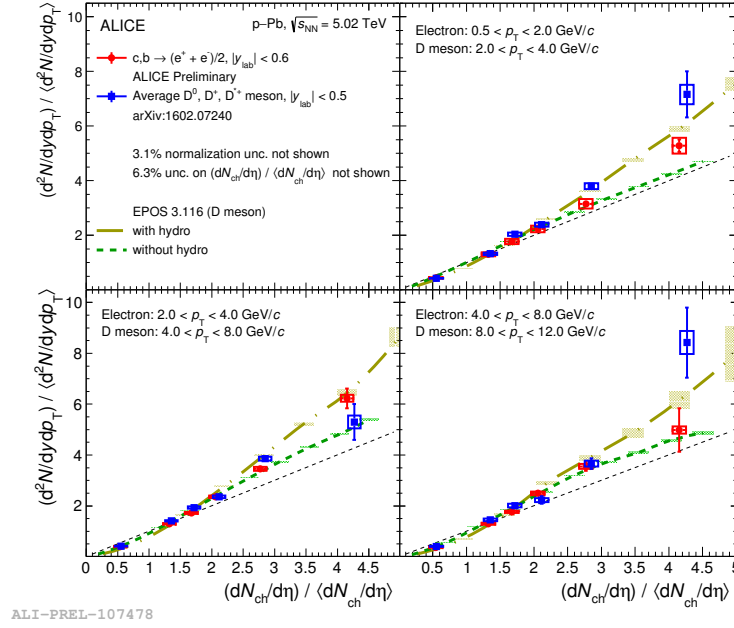


Figure 2: Self-normalised yields of D mesons and of electrons from heavy-flavour hadron decays as a function of the charged-particle multiplicity estimated at mid-rapidity measured in p-Pb collisions. The results of EPOS3 model calculations [7] are also shown.

the correlation distributions allow for a more quantitative comparison of the near-side peak properties. Figure 4 compares the near-side associated yields and the near-side peak widths extracted in pp and p-Pb collisions. Compatible values of the near-side observables are obtained in pp and p-Pb collisions. No modifications of the near-side peaks due to cold nuclear matter effects are observed in p-Pb collisions with the current uncertainties. Predictions by POWHEG+PYTHIA6 simulations, including nuclear shadowing effects for the nucleon parton distribution functions, are also in agreement with the measurements.

4. Conclusions

The D mesons self-normalised yields are measured as a function of the charged-particle multiplicity estimated at mid-rapidity and the trend can be explained by model calculations with MPI in pp collisions [5]. In p-Pb collisions a faster-than-linear increase of the self-normalised yields of D mesons and of electrons from heavy-flavour hadron decays as a function of the charged-particle multiplicity estimated at mid-rapidity is observed. The faster-than-linear increase suggests an interplay between MPIs and multiple binary nucleon-nucleon collisions in p-Pb interactions. The azimuthal

correlation distributions of D mesons and charged particles, measured in pp and p-Pb collisions, as well as observables describing near-side peak properties, are in agreement between each other within uncertainties. These observables are also well described by PYTHIA and POWHEG+PYTHIA6 Monte Carlo simulations.

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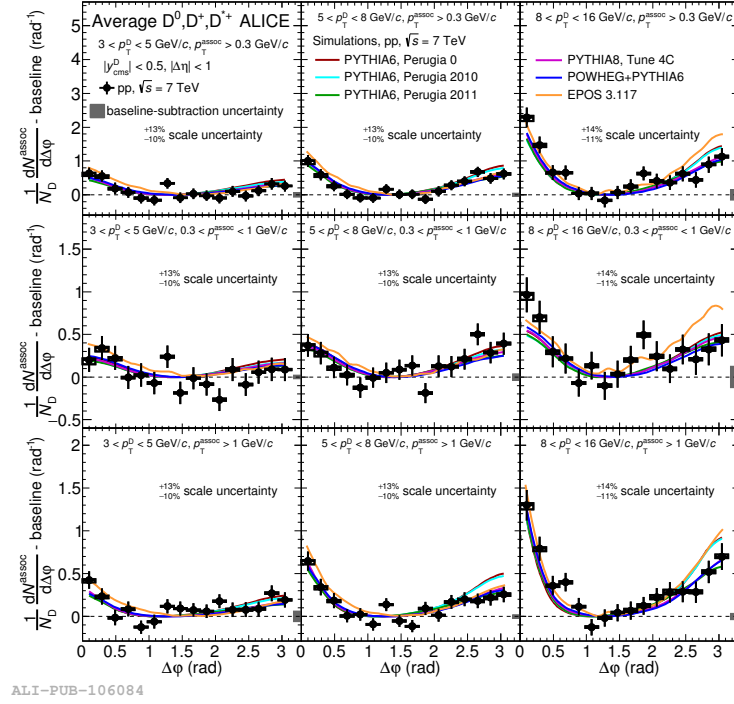


Figure 3: Azimuthal-correlation distributions of prompt D mesons with charged particles measured in pp collisions at $\sqrt{s} = 7$ TeV compared to expectations from Monte Carlo generators after the subtraction of the baseline.

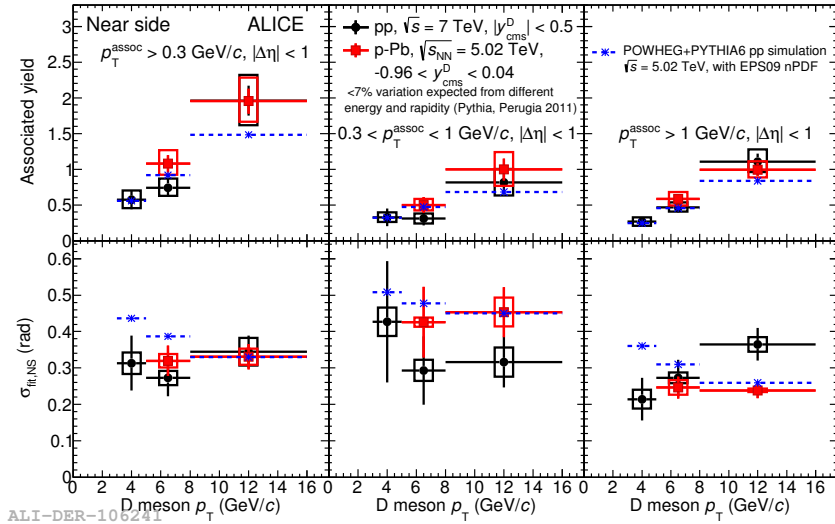


Figure 4: Comparison of the near-side peak associated yield (top row) and peak width (bottom row) in pp and p-Pb collisions with expectations from POWHEG+PYTHIA6 Monte Carlo generator.